

OPS/A

PRICE \$5.00



INSTRUCTION MANUAL



131-38 SANFORD AVE. • FLUSHING, N.Y. 11352
(212) 461-7000 • TWX #710-582-2631





Model OPS-1A

Serial No.

INSTRUCTION MANUAL

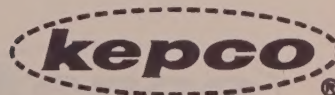
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2,992,379	3,112,439	3,241,042	3,275,948
2,992,386	3,128,423	3,243,690	3,303,411
3,028,538	3,131,344	3,243,749	3,303,412
3,056,905	3,210,619	3,275,925	3,303,415
3,088,053	3,226,628	3,275,927	3,305,763
3,092,757	3,241,054		

Canadian Patents: 733629 - 736084
Australian Patents: 263,835 - 264,975

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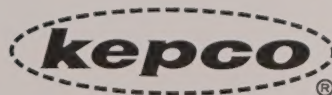


KEPCO, INC. • 131-38 SANFORD AVENUE • FLUSHING, N.Y. 11352 • (212) 461-7000 • TWX #710-582-2631 • Cable: KEPCOPOWER NEWYOR

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I. INTRODUCTION

SCOPE OF MANUAL:

....This instruction manual contains information for the installation, operation and maintenance of the KEPCO OPS-1, Operational Power Supply. Aside from the difference in mounting style, OPS-1, OPS-1A, and OPS-1B are equivalent.

Consequently, in this instruction manual the designation OPS-1 pertains to ALL three models unless otherwise indicated.

GENERAL DESCRIPTION:

....The Model OPS-1 is an entirely self-contained 1 watt Operational Power Supply, consisting of a unipolar operational amplifier, a power amplifier and all necessary auxiliary supplies. The OPS-1 is specifically designed for use with KEPCO operationally programmable power supplies, performing such functions as signal processing, translation of signals or it may be used for driving purposes. The OPS-1 can be used for most operational amplifier computational functions and it is especially suitable for those requiring a relatively high output power level. The OPS-1 provides a three terminal inverting amplifier with 80 db open loop gain, a 200 kc gain-band-width produce and a 100,000 volt/second slewing rate capability. Page 1-3 shows the front panel terminations of the OPS-1A and their relationship to the symbolic representations as used in the diagrams throughout the manual.

SPECIFICATIONS:

....Output Voltage:

0-20 volts, unipolar.

....Output Current:

0-50 milliamperes.

....Adjustable Current Limiting:

25% to 125% fully protected for all conditions of loading, from open to short circuit.

....Power Requirements:

105-125 or 210-250V AC, 50-65 cps.

....Open Loop DC Gain:

In excess of 80 db.

....Bandwidth, Unity Gain:

200 kc.

....Bandwidth, for 20 Volt Excursion:

1 kc (no load) 0.1 kc (400 Ω load).

....Bandwidth for 1 volt Excursion:

20 kc (no load) 2 kc (400 Ω load).

....Maximum Slewing Rate:

10⁵ volts per second.

....Regulation and Stability:

(Changes referred to the input offset voltage and loop current.)

Line: Less than 10 μ V and 50 nA input change for 105-125V AC line change.

Temperature: Less than 10 μ A and 50nA input change per °C.

Stability: Less than 10 μ V and 50nA input change over 8 hours at constant line voltage, load and ambient temperature.

Ripple and Noise: Less than 10 μ V rms.

....Built-In Reference:

-6.2V DC nominal (5.9 - 6.5V) reference potential and resistor (zener regulated) for reference and summing applications.

Reference Temperature Coefficient: 0.01% per °C.

Reference Stability: 0.01% per 8 hours for constant line, load and ambient temperatures

....Maximum Capacitive Loading:

0.001 μ f.

....Ambient Operating Temperature Range:

-20°C to +60°C.

....Storage Temperature:

-40°C to +85°C.

....Optional Enclosures:

OPS-1A: Bench-style enclosure, 4 1/4" H x 8 5/32" W x 5 5/8" D, with binding posts, switch/pilot light and trimming adjustment.

OPS-1A fits the RA-4 and RA-5 Rack Adapters.

OPS-1B: Plug-in housing, 2 11/16" H x 4 1/8" W x 13 3/16" D, fits RA 6-6 Rack enclosure.

II. TYPICAL APPLICATIONS

1. Precision nulling voltage reference.
2. Programmable voltage or current source.
3. Standard cell repeater.
4. DC impedance transformer (high to low).
5. Buffer amplifier for potentiometric divider.
6. Potentiostat signal repeater (electrolysis).
7. Adjustable gain DC instrumentation amplifier.
8. Recorder amplifier/driver.
9. Meter amplifier.
10. Photocell amplifier.
11. Resistance-to-voltage translator for thermistors or photo resistors.
12. DC servo amplifier.
13. Integrator.
14. Summer (all operational algebraic manipulations).
15. Analog simulation and problem solving.

III. OPERATIONAL AMPLIFIERS AND SYMBOLOGY

Originally the term "operational amplifier" was used in connection with analog computers to describe amplifiers that performed various mathematical "operations". By the proper selection of feedback components, operational amplifier circuits can be used to add, subtract, average, integrate and even differentiate.

The high gain inverting DC amplifier of OPS-1 can be symbolically represented as shown in Figure 3.1.

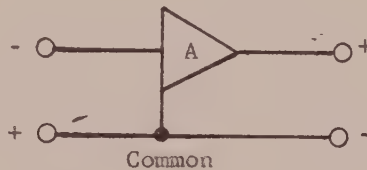
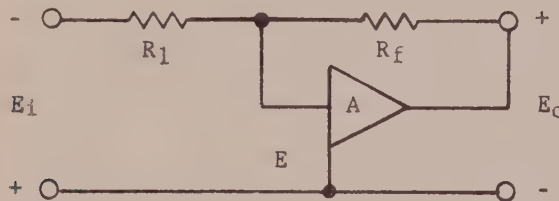


FIGURE 3.1

Feedback is added to the amplifier by means of proportioning resistors R_1 and R_f (see Figure 3.2).



$$G = \frac{R_f}{R_1}$$

FIGURE 3.2

By drawing the polarities E_1 and E_0 as in Figure 3.2, the closed loop gain (G) can be regarded as a positive number.

$$E_0 = E_1 \left[\frac{R_f}{R_1} \right] \quad \text{where} \quad \frac{R_f}{R_1} = G$$

ϵ is the error voltage which is multiplied by A , the open loop gain, to produce E_0 . Because A is very large, ϵ is quite small, approaching zero, so that the input terminal of the amplifier is a virtual ground, or null point. The operational gain (G) is very nearly independent of A (provided $A \gg G$).

The input impedance of the DC (operational) amplifier is always equal to the input resistor, R_1 , because the null point resistance is virtually zero.

The output impedance is very low, being the open loop impedance of the output circuit divided by the loop gain $[A(\text{db}) - G(\text{db})]$.

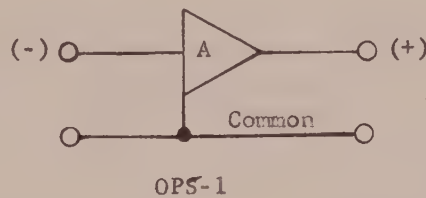
The input impedance can, in theory, be set to any desired value simply by selecting R_1 . Provided the ratio of R_f/R_1 is maintained constant, the gain is unaffected by changes made simultaneously in R_f and R_1 . In practice, the maximum input resistance will depend on the amount of tolerable noise pickup. Tens of megohms can be used for R_1 in special integrator circuits where the noise is swamped by an exceptionally long time constant. The minimum input resistance will depend on how much current the "input" source, or reference, is able to deliver.

In a sense, the operational circuit is a current-driven device, since its input impedance (at the null junction) is nearly zero. It does not matter what the input voltage may be, so long as it can deliver the requisite current through whatever input resistor may be selected. Usually this current is picked first, by determining a value for R_1 based on the expected input voltage. R_f is then selected to provide the desired gain for the wanted output voltage.

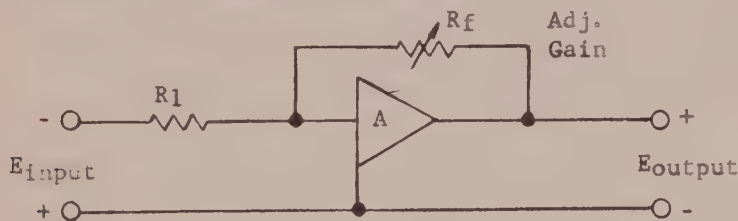
IV. SUGGESTED CIRCUITS

The following diagrams illustrate some of the basic OPS-1 connections:

The OPS-1 is represented schematically as a high-gain inverting amplifier with gain A.

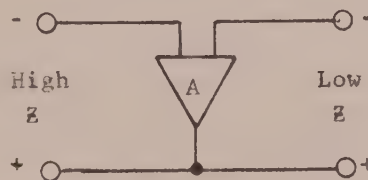


Operationally, connected as a conventional amplifier, the OPS-1 circuit resembles that of an operational amplifier.

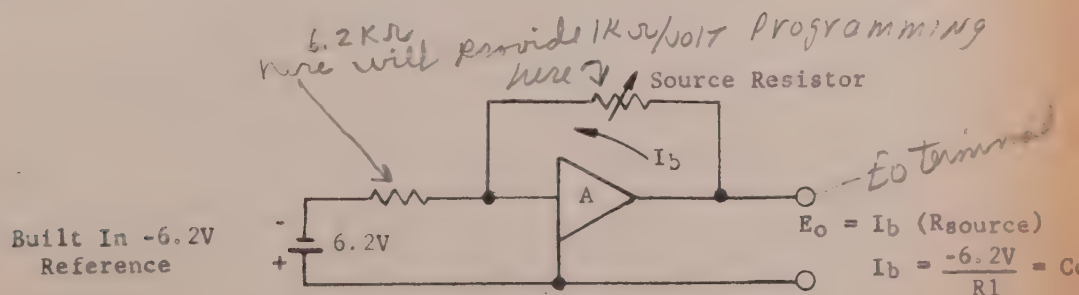


operational gain G
equals R_f/R_1
input $Z = R_1$

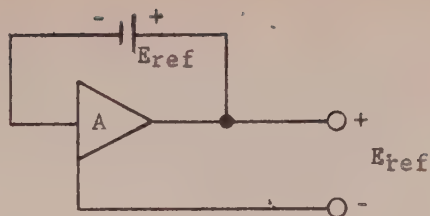
As an impedance transformer, OPS-1 is connected as a unity gain, noninverting amplifier.



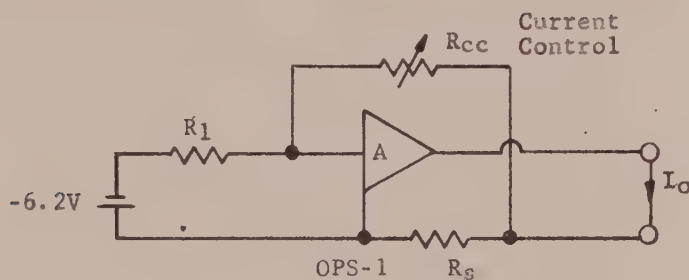
As a resistance to voltage translator, OPS-1 uses its built-in reference to supply a constant current (selectable) to the source resistor. The output voltage is the product of this current, times the source resistance. The output voltage is thus linearly related to resistance.



STANDARD CELL REPEATER:



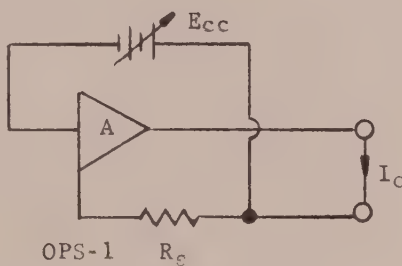
CURRENT SOURCE USING BUILT-IN REFERENCE:



$$I_b = \frac{-6.2V}{R_1}$$

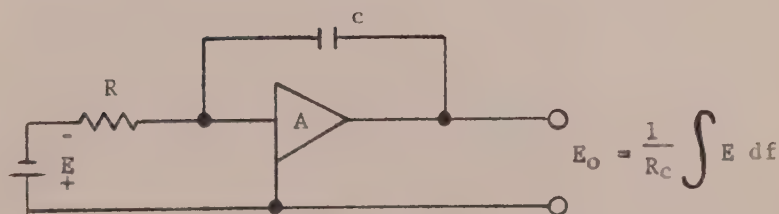
$$I_o = I_b \left(\frac{R_{cc}}{R_s} \right) + I_b$$

CURRENT SOURCE CONTROLLED BY VOLTAGE:



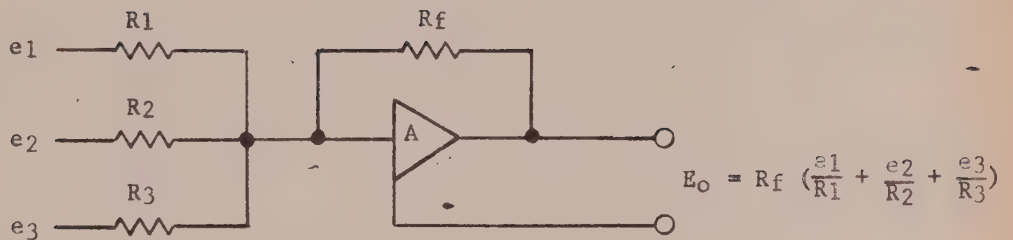
$$I_o = \frac{E_{cc}}{R_s}$$

INTEGRATOR:



$$E_o = \frac{1}{R_c} \int E \, df$$

SUMMER:



V. DYNAMICS

The AC compensation of the OPS-1 is deliberately underdamped. This means that some ringing may be observed on a squarewave program. Compensation may be effected by the addition of a small capacitor 0.0001 μ f to 0.01 μ f across the feedback resistor R_f . The value of this capacitor will depend on the value of R_f and on the amount of stray capacitance introduced by the wiring.

Like any operational amplifier, OPS-1 is sensitive to capacitive loads. The load capacitance should always be minimized so as to avoid compromise of the 100,000 volt per second slewing rate.

In no event should the load capacitance exceed 0.001 μ f, or oscillation will result. If it is desired to capacitively slow the response of OPS-1 or reduce the bandwidth to decrease the output noise, capacitors should be connected across the feedback terminals, not the output terminals.

VI. CONNECTIONS

OPS-1 is equipped with a barrier strip which will accept ordinary wire connections and a printed circuit connector which mates with Cinch Connector Part No. 250-12-37-200. AC (primary power) is connected either via a three-terminal PC connector, AMP Part No. 582380-9, or by means of solder lugs on the main board (PCB-1). When connecting to the terminals of OPS-1, care should be exercised to separate the AC power connections from the DC connections. Any connection to the null junction (Terminal 1) should be made by means of shielded wire.

AC POWER:

OPS-1 is wired for 115V AC (105-125V AC), 50-440 cps power. For operation at 230V AC (210-250V AC), remove the jumpers A - B and C - D from the transformer Terminals 1 - 2 and 3 - 4. Connect a new jumper between Terminals 2 - 3 (B - C).

AUXILIARY SUPPLIES:

OPS-1 is equipped with provision for four (4) auxiliary supplies: +18V, -18V, +6.2V and -6.2V.

The + 18V supply appears at Terminal 11. The -18V supply appears at Terminal 5. These potentials are available for external use in light current application (up to 10 milliamperes).

The +6.2V supply is intended for trimming applications (see Null Compensation). It is connected in series with a 500K ohm resistor (R406) to Terminal 10. Maximum loading: 1 milliampere.

The -6.2V supply is an optional zener reference source which, if installed, provides -6.2V DC via R411 to Terminal 4. R411 may either be installed as a 1 milliampere (approximately) reference resistor, or may be jumpered so that the -6.2V DC appears directly at Terminal 4 (for use with an external reference).

OUTPUT:

The positive output of OPS-1 is the terminal from which the feedback elements are connected back to the null junction. The positive output appears at Terminal 12. The negative output of OPS-1 is the common terminal for both input and output. A jumper is installed on PCB-6 between MINUS OUTPUT and MINUS ERROR. If this jumper is removed, the minus error (Terminal 8) must be connected to the minus output (Terminal 9) externally.

This connection provides a means of remote error sensing in that the two terminals can be connected together remotely, at a load. Positive lead remote error sensing would be accomplished by connecting the feedback element directly from the positive terminal of the load, rather than Terminal 12.

VII. OPERATION

RANGE:

The output voltage range for linear response is 0-20V DC. In all programs, care must be exercised to make certain that the output remains within its linear region. Clipping or other forms of distorted response will result if the output is allowed to go outside of these limits.

LOADING:

The total load and control current capability of OPS-1 is 50 milliamperes. Load current is computed by dividing the maximum output voltage by the load resistance. Control current is computed by dividing the maximum input voltage by the coupling (reference) resistance. The sum of these two currents must be within the maximum current limit.

MAXIMUM CURRENT ADJUST:

The overload current limit setting may be adjusted by varying the setting of trimmer R508 on PCB-5. This adjustment may be made by shorting the output of OPS-1 through a milliammeter, and adjusting R508 for the maximum short circuit current.

NOTE: The short circuit setting should be approximately 25% greater than the intended maximum load plus control current sum.

CIRCUIT TRIMMING:

There are two separate nonideal characteristics of OPS-1 which must be accounted for in any operational setup. One is the offset voltage that is measured at the output when the feedback terminals are shorted, and there is no input. The other is the loop (leakage) current that flows through the feedback element when no input or reference sources are connected. This current can produce an output voltage when the impedance of the feedback element is large.

OFFSET:

A zeroing control is provided on terminal board PCB-4 to cancel to the offset voltage of OPS-1. This control is trimmer R405. Zeroing is properly accomplished by shorting the feedback terminals (Terminal 12 to Terminal 1), and adjusting R405 until a sensitive voltmeter at the output reads zero.

LEAKAGE:

The +6.2V source and 500K trim resistor (K406) provide the compensation current (at Terminal 10) that can be used to null the loop (leakage) current in the feedback element. To effect compensation, a 1 - 2 megohm rheostat potentiometer is connected from Terminal 10 to the null junction (Terminal 1) using shielded wire. With no other input, connect successively larger resistors across the feedback terminals (12 - 1), while adjusting the potentiometer for zero output voltage, as read on a sensitive output meter.

Note: As the feedback resistance R_f becomes very large, the sensitivity of the detector is increased. For example, with R_f equal to 1 megohm, 1 volt of output represents only 1 microampere of loop (leakage) current. With care, the net leakage can be reduced to just a few nanoamperes... (1 nanoampere equals 1 millivolt across 1 megohm).

In OPS-1A (bench case), the compensating control is mounted on the front panel and wired between Terminal 10 and Terminal 1. Leakage compensation has the effect of raising the impedance looking into the feedback terminals. When connected as a DC impedance transformer, the feedback terminals are the "input", so the input impedance will be directly proportional to the amount of residual current. With careful adjustment, the input impedance can be raised to $10^7 - 10^8$ ohms.

VIII. CIRCUIT DESCRIPTION:

OPS-1 consists of five (5) plug-in printed circuit cards and one mother board (PCB-1) on which the power transformer and terminal connectors are also mounted.

PCB-2 contains a full wave bridge rectifier and filter circuit, zener regulated by CR205, to produce a stable 25V DC potential as the "raw DC" for the output stage of OPS-1.

PCB-3 contains a dual voltage power supply delivering a regulated $\pm 18V$ DC to the amplifier circuits of OPS-1. These voltages are regulated by means of zener diodes CR304 and CR305, fed through a current regulator consisting of Q301, CR303 and R305.

PCB-4 contains the preamplifier, a complementary pair of NPN - PNP transistors, which form the input stage of OPS-1. These transistors are mounted inside of a heavy copper enclosure which acts as a thermal shunt to maintain their relative temperature constant. PCB-4 also contains the two (2) $\pm 6.2V$ DC zener diodes and their feed resistors, plus the zeroing trimmer, R405.

PCB-5 contains a two-transistor DC amplifier, Q501 and Q502. Transistor Q503 provides the current limit adjustment along with R508. This board also contains the two (2) AC lag networks which shape the output gain-frequency characteristic.

PCB-6 is the output amplifier. It contains a Darlington connected pair with Q601 driving Q602, the output transistor. Diode CR601 is wired across the output to prevent the application of reverse potential.



REPLACEMENT PARTS LIST

PRINTED CIRCUIT BOARD ASSEMBLY #1 MODEL OPS-1A Code 6-365

Page 1 of 1

SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
C101,102	2	Capacitor, Mylar 0.01 μ f, 200 v, 10%	Sprague Electric 192P10302	117-0353
F101	1	Fuse, Instantaneous 1/4 a, 250 v	Bussman AGC-1/4	141-0005
T101	1	Transformer	Kepco Magnetics	100-1465

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PRINTED CIRCUIT BOARD ASSEMBLY #2 MODEL OPS-1 Code 6-365

SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
C201	1	Capacitor, Electrolytic, Pigtail 22 μ F, 100 V	General Electric 76F02MM220	117-0490
C202	1	Capacitor, Electrolytic, Pigtail 100 μ F, 25 V	General Electric 76F02KM101	117-0459
C203	1	Capacitor, Pigtail 50 μ F, 50 V, 20%	General Electric 76F02LM500	117-0519
CR201, 202, 203, 204	4	Rectifier, Silicon, Pigtail	Semicon Inc. SM-140	124-0028
CR205	1	Zener Diode	General Instrument 1N 2987B	121-0050
R201	1	Resistor, Fixed, Power, Axial 75 ohm, 5 W, 5%	Ward Leonard 5X75	115-0403

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PLEASE NOTE: THE MANUFACTURER'S NAME AND PART NUMBER IS GIVEN FOR EACH ITEM ON REPLACEMENT PARTS LIST. THIS IS FOR THE CONVENIENCE OF THE CUSTOMER. IF A CUSTOMER WISHES TO ORDER EQUIVALENT PARTS FROM AN ALTERNATE SOURCE, HE SHOULD CONTACT THE MANUFACTURER OF THE EQUIVALENT PARTS TO OBTAIN THE NECESSARY INFORMATION.

PRINTED CIRCUIT BOARD ASSEMBLY #3 MODEL OPS-1 Code 6-365
Page 1 of 1

SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
C301	1	Capacitor, Alumalytic, Pigtail 33 μ f, 65 v	General Electric	117-0461
C302, 303	2	Capacitor, Electrolytic, Pigtail 100 μ f, 25 v	General Electric 76F02KM101	117-0459
CR301, 302	2	Rectifier, Silicon, Pigtail	Semicon Inc. SM-140	124-0028
CR303	1	Zener Diode	North American AN267	121-0028
CR304, 305	2	Zener Diode	Motorola 1N3026B	121-0036
Q301	1	Transistor, Silicon, PNP	Delco 2N3215	**119-0063
R301	1	Resistor, Fixed, Power, Axial 6 K ohm, 3 w, 3%	Hardwick Hindle 9/16 GA6K LTC	115-1155
R302	1	Resistor, Fixed, Molded 39 ohm, 1/2 w, 5%	Allen Bradley EB3905	115-1242
R303	1	Resistor, Fixed, Molded 390 ohm, 1/2 w, 5%	Allen Bradley EB3915	115-0883
R304	1	Resistor, Fixed, Molded 820 ohm, 1/2 w, 10%	Allen Bradley EB8211	115-0480
R305	1	Resistor, Fixed, Power, Axial 250 ohm, 3 w, 5%	Hardwick Hindle 9/16 GA-250-LTC	115-0961

****See Field Replacement Page.**



REPLACEMENT PARTS LIST

PRINTED CIRCUIT BOARD ASSEMBLY #4 MODEL OPS-1A Code 6-365

Page 1 of 1

SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
CR401,402	2	Zener Diode	International Rect. 1N821	121-0041
Q401	1	Transistor, Silicon, NPN	General Electric	**119-0054
Q402	1	Transistor, Silicon, PNP	Hughes	**119-0055
R401	1	Resistor, Fixed, Precision, WW 100 ohm, 1 w, 5%	Tepro Electric TS1W	115-1638
R402	1	Resistor, Fixed, Precision, WW 36 K ohm, 2 w, 5%	Tepro Electric TS2C	115-1313
R403	1	Resistor, Fixed, Precision, WW 13 K ohm, 1 w, 5%	Tepro Electric TS1W	115-1309
R404	1	Resistor, Fixed, Power, Axial 10 ohm, 3 w, 5%	Hardwick Hindle 9/16 GA-10-LTC	115-1160
R405	1	Resistor, Variable, WW 20 K ohm, 1/2 w, 10%	Bourns 3067P-1-203	115-1728
R406	1	Resistor, Fixed, Metal Film 500 K ohm, 1 w, 1%	IRC Type CES	115-1801
R407,410	2	Resistor, Fixed, Power, Axial, WW 1.6 K ohm, 1 w, 5%	Tepro Electric TS1W	115-1695
R408,409	2	Resistor, Fixed, Precision, WW 1.3 K ohm, 1 w, 3%	Tepro Electric TS1W	115-1310

**See Field Replacement Page.

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REPLACEMENT PARTS LIST

PRINTED CIRCUIT BOARD ASSEMBLY #5 MODEL OPS-1 Code 6-365

Page 1 of 1

SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
C501,502	2	Capacitor,Mylar 0.4 μ f, 200 v, 10%	Hopkins Eng. P42MK	117-0128
Q501	1	Transistor,Silicon,PNP	Hughes	**119-0055
Q502,503	2	Transistor,Silicon,NPN	General Electric	**119-0054
R501,503	2	Resistor,Fixed,Molded 20 ohm, 1/2 w, 5%	Allen Bradley EB2005	115-0508
R502	1	Resistor,Fixed,Molded 12 K ohm, 1/2 w, 5%	Allen Bradley EB1235	115-1341
R504	1	Resistor,Fixed,Molded 2.2 K ohm, 1/2 w, 5%	Allen Bradley EB2225	115-0339
R505	1	Resistor,Fixed,Molded 1 K ohm, 1/2 w, 5%	Allen Bradley EB1025	115-0340
R506	1	Resistor,Fixed,Molded 1.8 K ohm, 1/2 w, 5%	Allen Bradley EB1825	115-0462
R507	1	Resistor,Fixed,Molded 4.7 K ohm, 1/2 w, 5%	Allen Bradley EB4725	115-0350
R508	1	Resistor,Variable 3 K ohm, 1/2 w, 10%	Bourns 306/P-1-302	115-1668
R509	1	Resistor,Fixed,Molded 5.6 K ohm, 1/2 w, 5%	Allen Bradley EB5625	115-0559

**See Field Replacement Page.

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kepcO REPLACEMENT PARTS LIST

PRINTED CIRCUIT BOARD ASSEMBLY #6 MODEL OPS-1 Code 6-365

Page 1 of 1

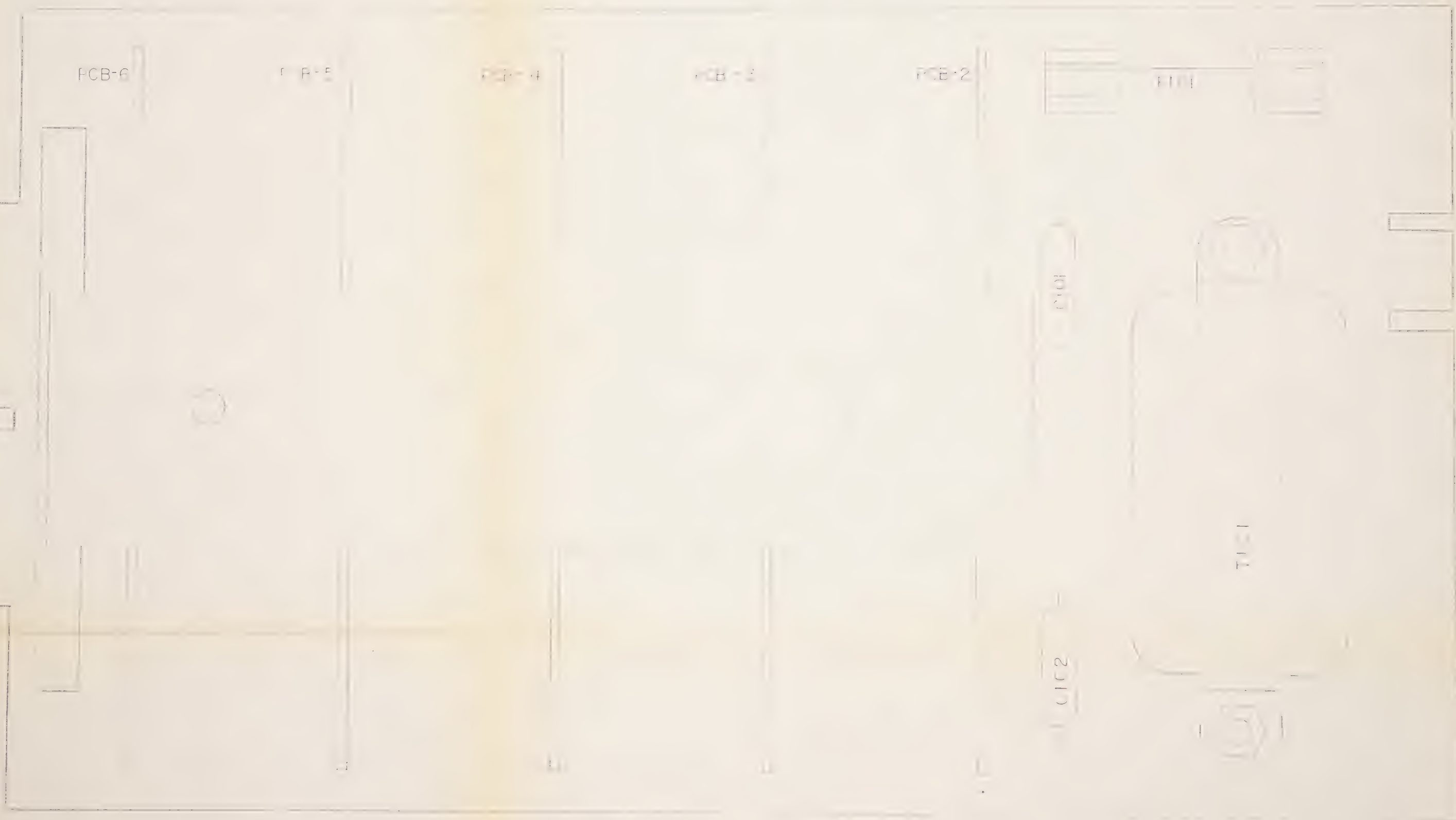
SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
CR601	1	Rectifier, Silicon, Pigtail	Semicon Inc. SM-140	124-0028
Q601	1	Transistor, Silicon, PNP	Hughes	**119-0055
/Q602	1	Transistor, Silicon, PNP	Delco 2N3215	**119-0063
R601	1	Resistor, Fixed, Molded 47 K ohm, 1/2 w, 5%	Allen Bradley EB4735	115-0248
R602	1	Resistor, Fixed, Molded 240 ohm, 1/2 w, 5%	Allen Bradley EB2415	115-0484
R603	1	Resistor, Fixed, Precision, WW 100 ohm, 1 w, 5%	Tepro Electric TS1W	115-1638

**See Field Replacement Page.

FIELD REPLACEMENT LIST

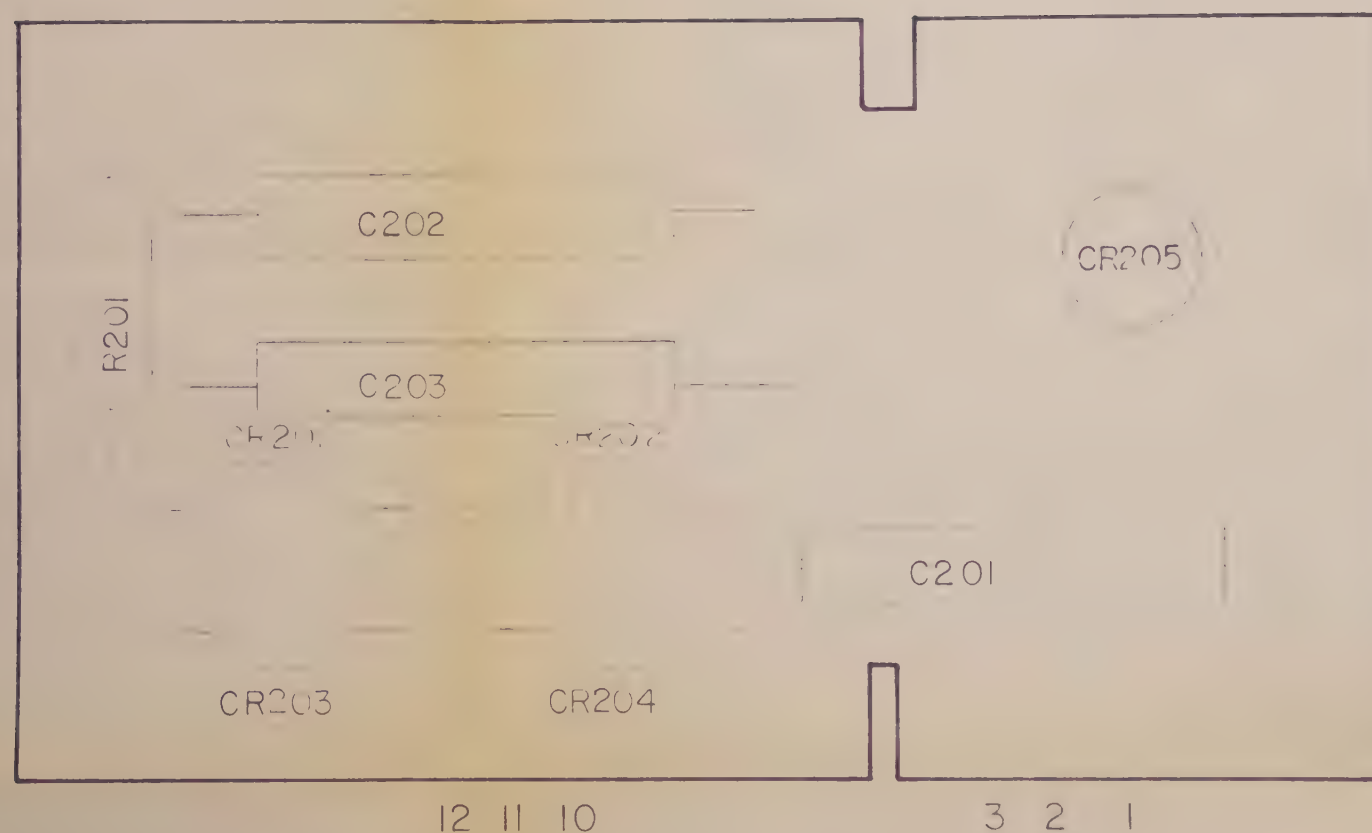
Kepco Part No.	Description	Recommended Replacement	
		<u>MFR.</u>	<u>MFR. No.</u>
119-0016	Transistor, PNP	Delco	2N174
119-0020	Transistor, PNP	RCA	2N398A
119-0022	Transistor, PNP	Tung Sol	2N1707
		Texas Instrument	2N404
119-0024	Transistor, NPN	General Inst.	2N1605
		RCA, General Elec.	2N388
		Texas Instrument	
		Sylvania, Texas	2N1308
		Instrument	
119-0034	Transistor, PNP	Delco	2N1172
		Hughes	2N1131A
119-0035, 0036,0037	Transistor, PNP	Motorola	2N1167
		Clevite	CTP 3553
119-0038	Transistor, NPN	Transitron	ST29
119-0048	Transistor, Unijunction	General Electric	2N1671A
119-0049	Transistor, PNP	Delco	2N669
119-0054	Transistor, NPN	General Electric	2N338
			2N336A
119-0055	Transistor, PNP	Hughes	2N1131A
119-0056	Transistor, NPN	General Electric	2N336A
119-0057	Transistor, PNP	Delco	DTG-1200
119-0059	Transistor, NPN	RCA	2N3053
119-0060	Transistor, NPN	RCA	2N3054
119-0061	Transistor, NPN	RCA	2N3055
119-0065	Transistor, PNP	Hughes	2N3225
119-0067	Transistor, PNP	Delco	DTG-2400
119-0068	Transistor, NPN	RCA	40250
119-0069	Transistor, NPN	RCA	40251
119-0070	Transistor, NPN	RCA	2N3442

REV	DATE	BY	APP



KEPCO, INC. FLUSHING, N.Y.			
TITLE PCB-1 COMPONENT LOCATION			
DRAWN SK	CHECKED _____	APPROVED _____	DATE 5-5-65
MODEL NO. OPS-1 & OPS-1A		SCALE 1" = 10'	
DRAWING NO. CM04970			

CM04971



KEPCO INC.
FLUSHING, N.Y.

TITLE
PCB-2 COMPONENT LOCATION

DRAWN	CHECKED	APPROVED	DATE
SK			5-5-65

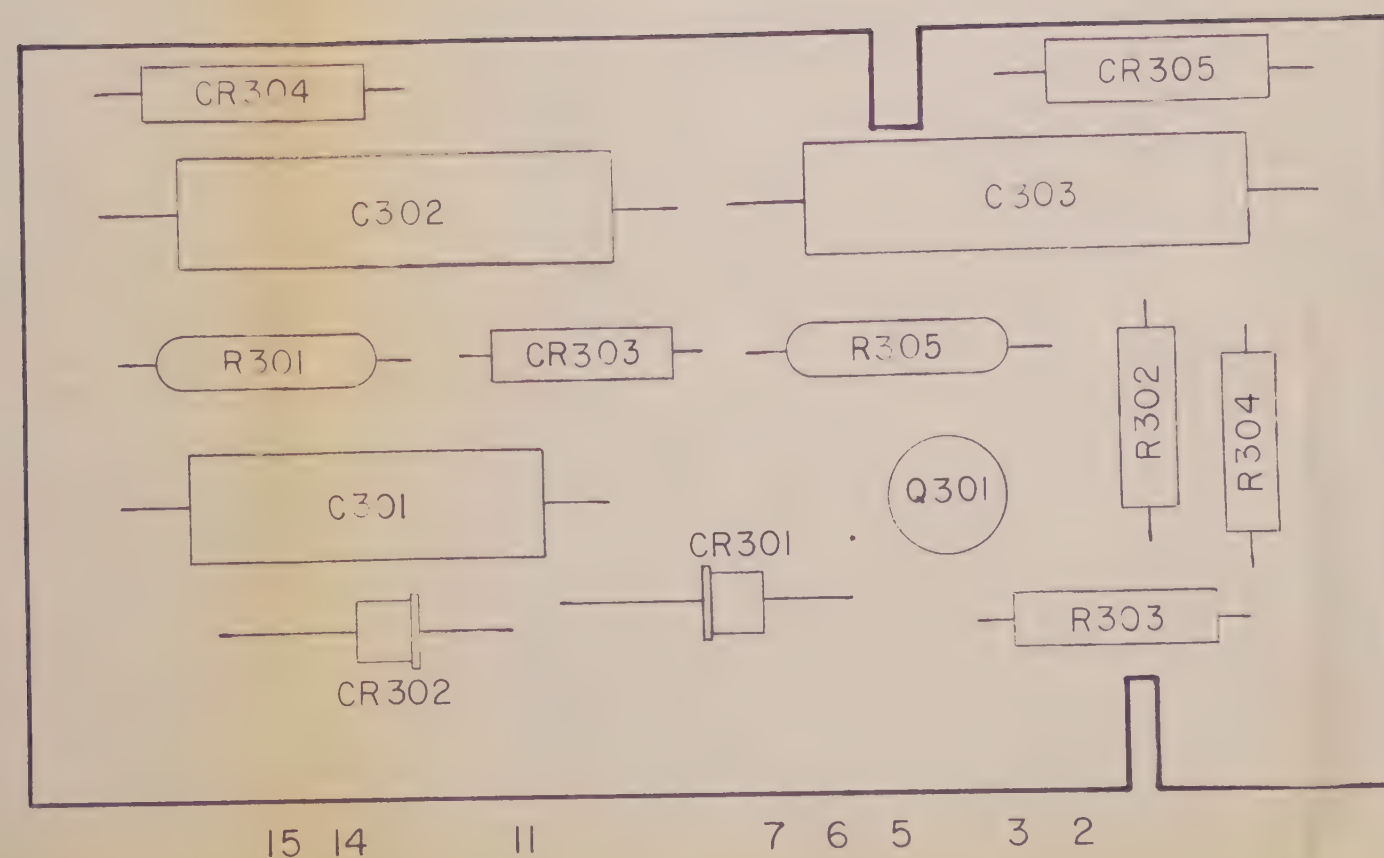
MODEL NO.	PART NO.	SCALE
OPS-1 & OPS-1A		1/1

DWG. NO. CM04971

CM04972

REVISIONS

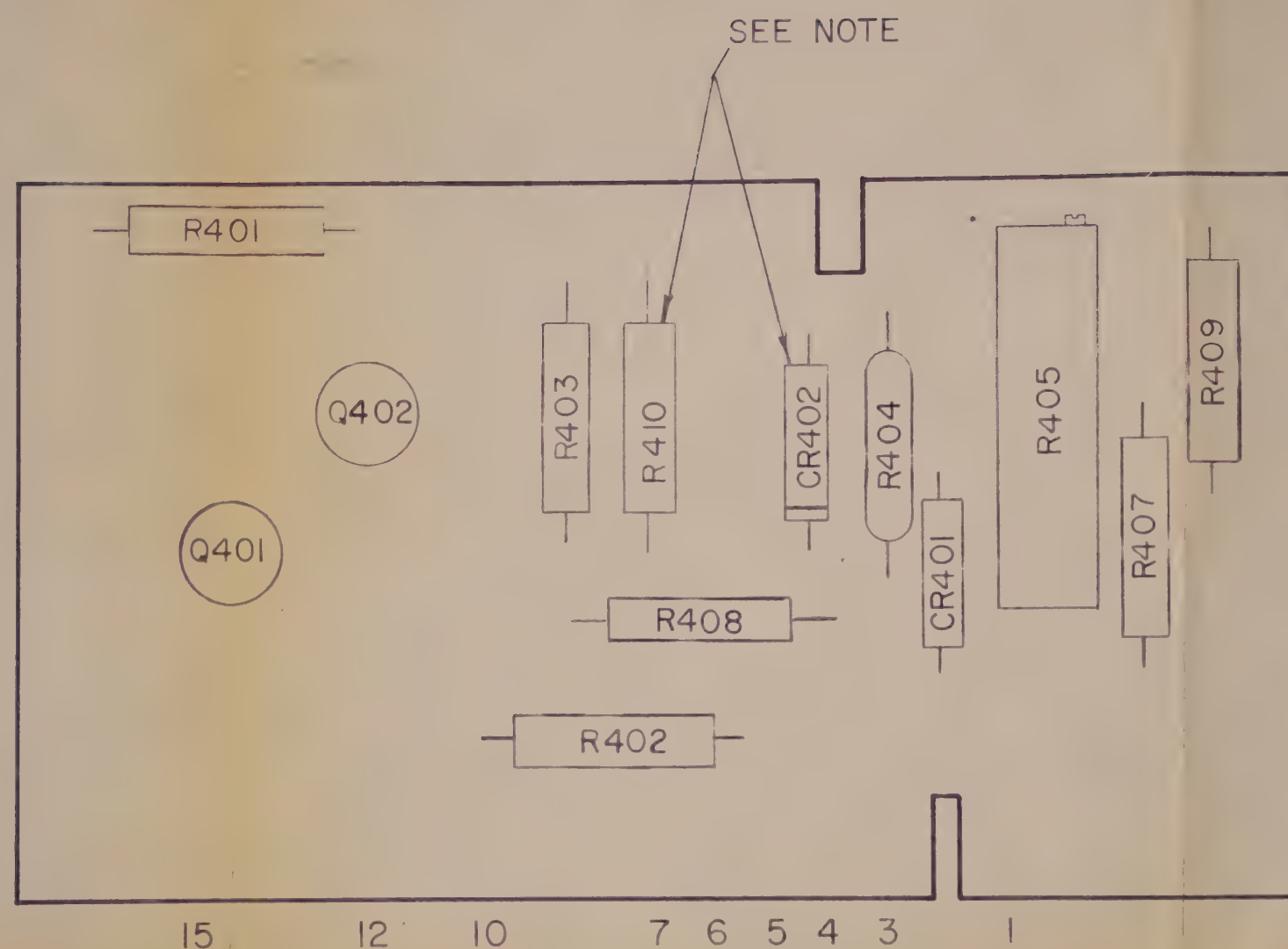
DRAWN CHKD. APPD. DATE

KEPCO INC.
FLUSHING, N. Y.TITLE
PCB-3 COMPONENT LOCATION

DRAWN	CHECKED	APPROVED	DATE
C.S.			5-5-65
MODEL NO.	PART NO.	SCALE	
OPS-1 & OPS-1A		NONE	

DWG. NO. CM04972

TOLERANCE UNLESS OTHERWISE SPECIFIED: FRACTIONS $\pm 1/64$ DECIMALS $\pm .005$ ANGLES $\pm 1/2^\circ$



NOTE:

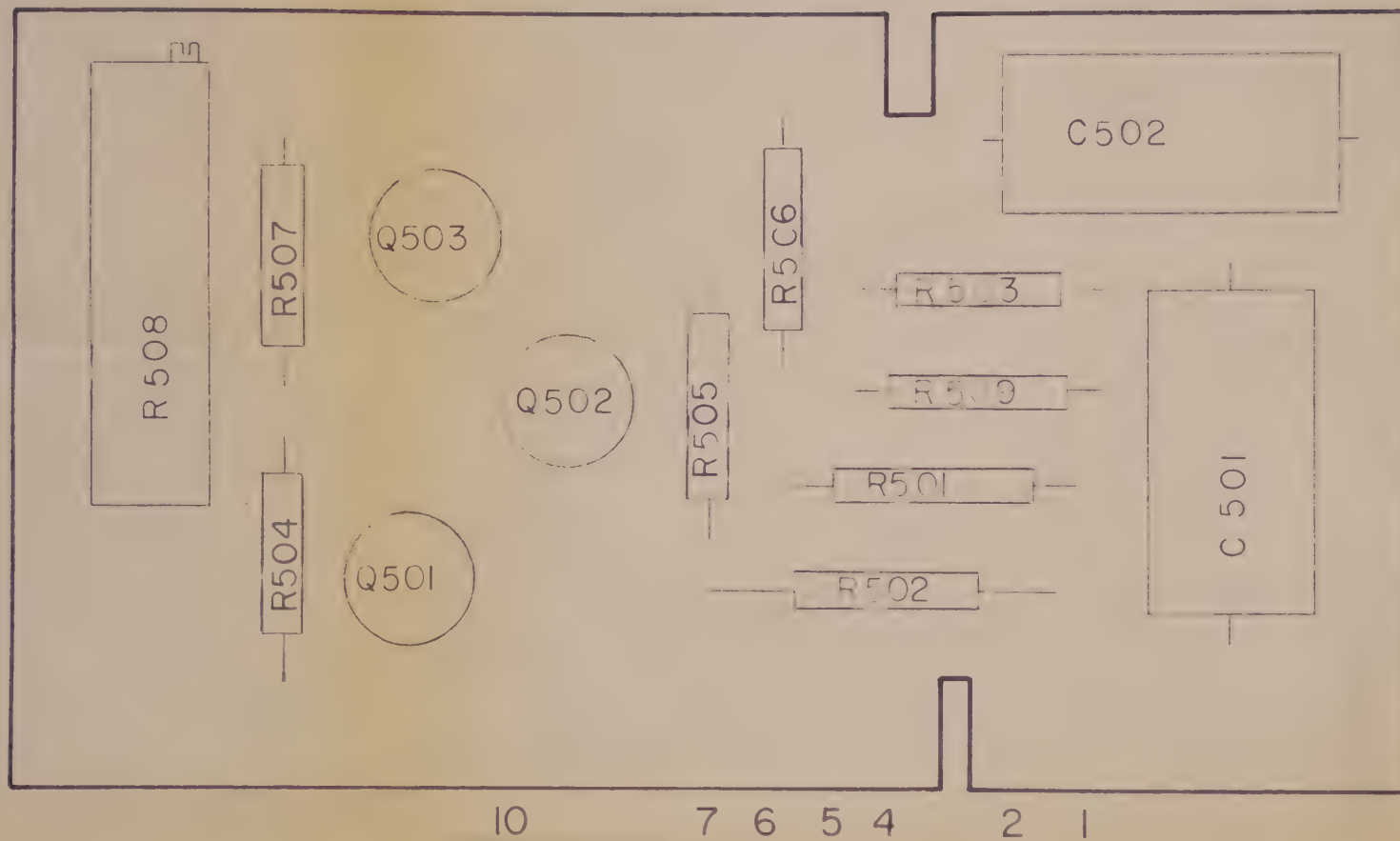
1. R410 AND CR402 USED IN OPS-I & OPS-IA FOR 6.2V REFERENCE.
2. R410, R511 AND CR402 NOT USED IN FG-100

KEPCO INC.
FLUSHING, N.Y.TITLE
PCB-4 COMPONENT LOCATION

DRAWN	CHECKED	APPROVED	DATE
C.S.			5-4-65

MODEL NO.	PART NO.	SCALE
OPS-I & OPS-IA		NONE

DWG. NO. CMO4973

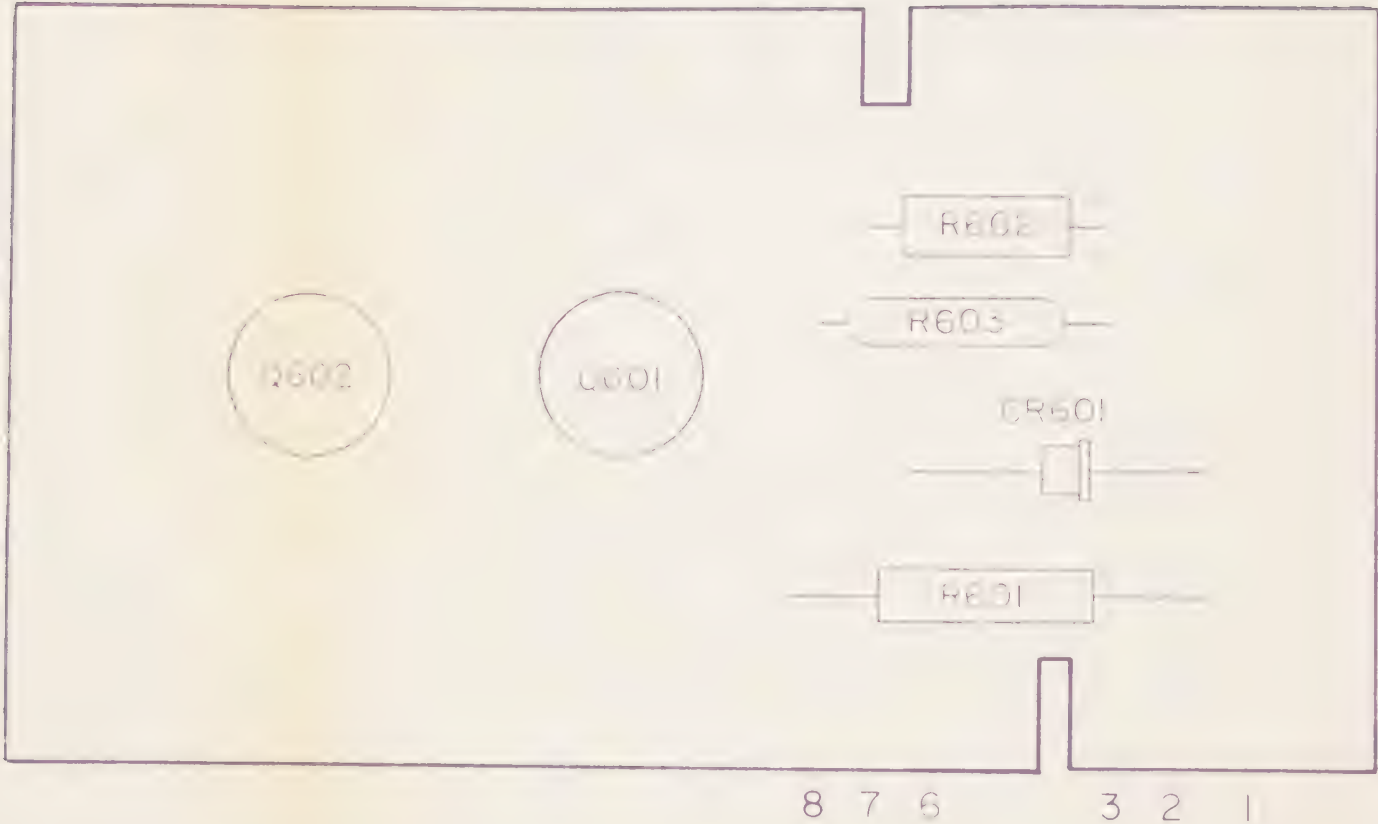


KEPCO INC
FLUSHING, N.Y.

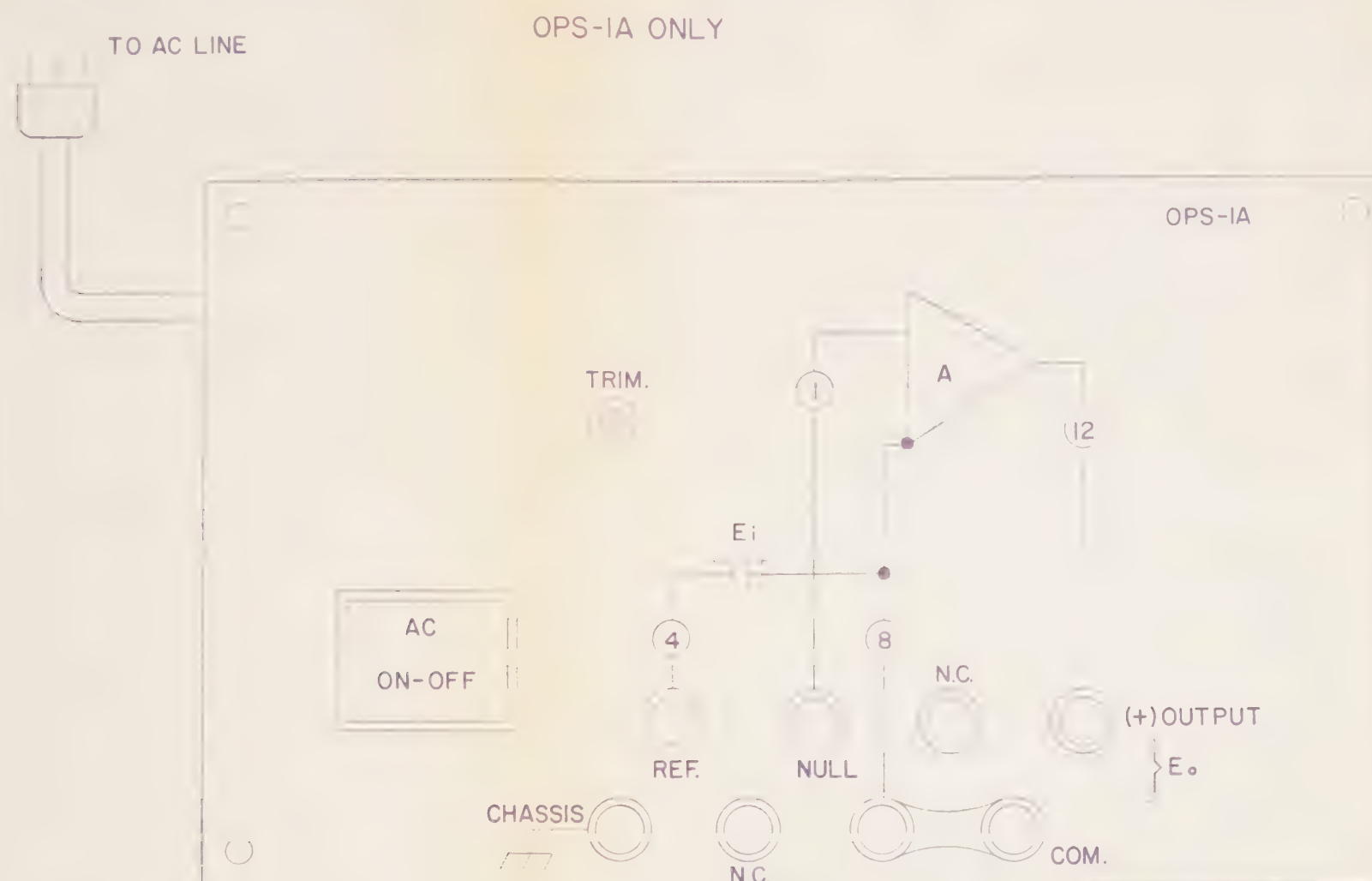
TITLE PCB-5 COMPONENT LOCATION			
DRAWN SK	CHECKED	APPROVED <i>[Signature]</i>	DATE 6 4 65
MODEL NO OPS-1 & OPS-1A		PART NO	DATE / /
DWG NO CM04974			

CMO4975

REVISE	DATE	BY	APP	DATE



KEPCO INC. FLUSHING, N.Y.			
PCB-6 COMPONENT LOCATION			
DESIGNED C.S.	CHECKED <i>[Signature]</i>	DATE 5-4-65	SCALE NONE
MODEL NO. OPS-IA&OPS-I		PART NO.	SCALE NONE
DWG. NO. CMO4975			



NOTE:
ENCIRCLED NUMBERS ARE TERMINALS ON P-102, WHICH IS PART OF PCB-1

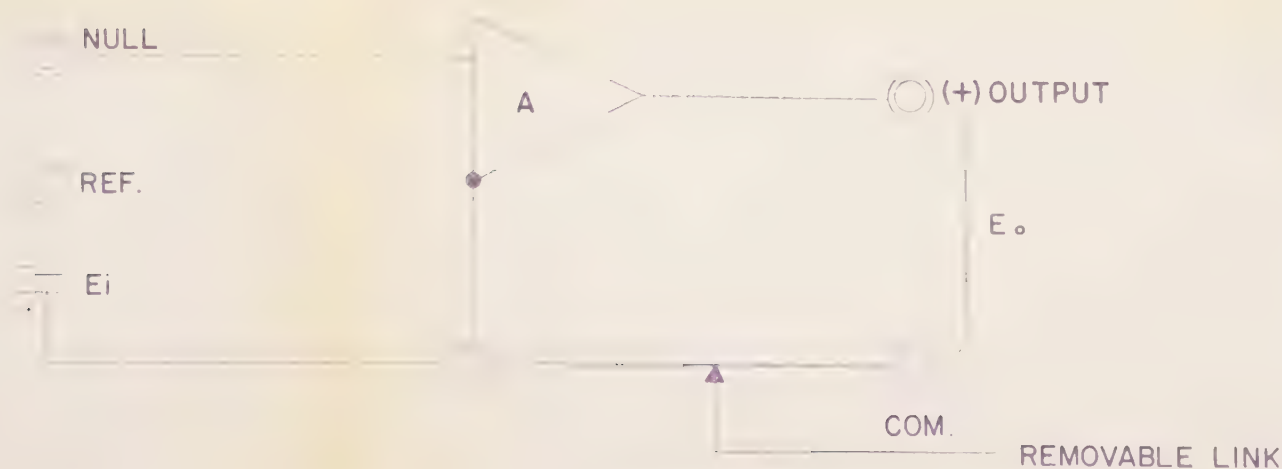


FIG.2-3 OPS-1A,TERMINATIONS AND SYMBOLIC REPRESENTATION

KEPCO INC.
FLUSHING, N. Y.

TITLE FIG.2-3 TERMINATIONS AND SYMBOLIC REPRESENTATION

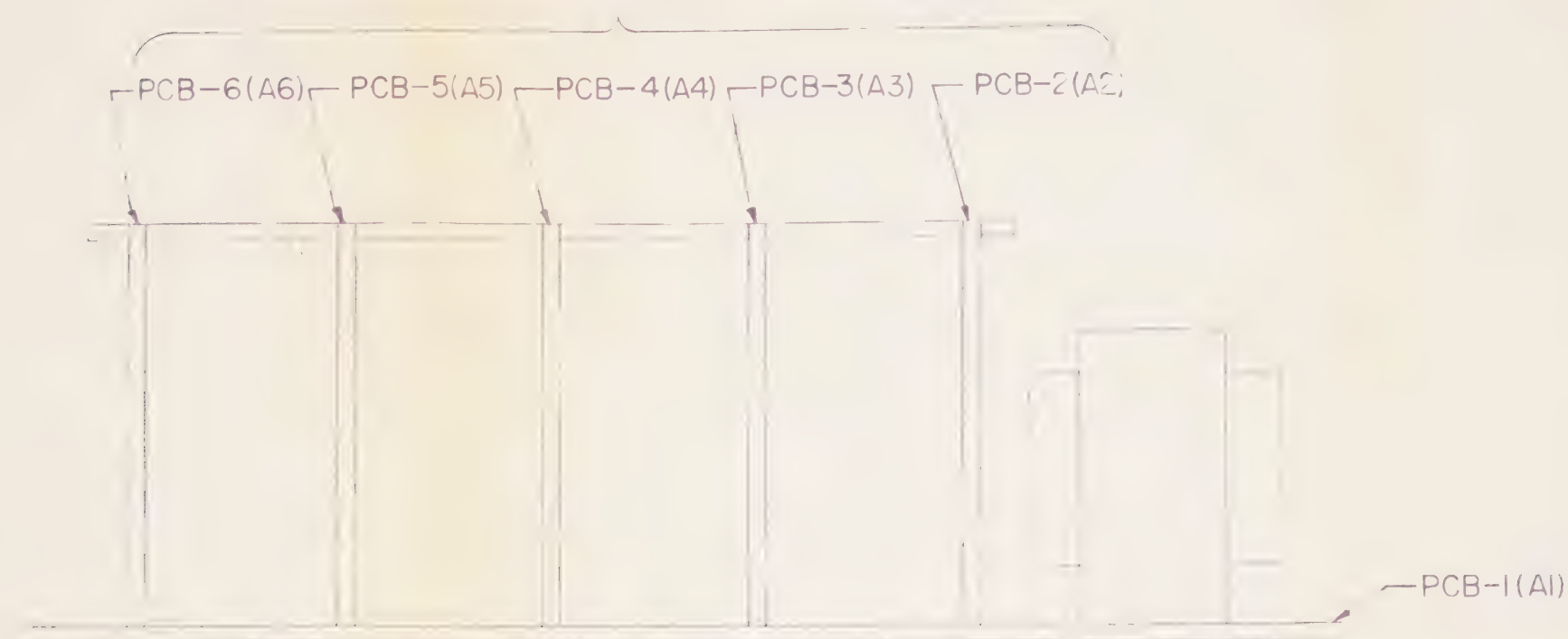
DRAWN V.S.	CHECKED [Signature]	APPROVED [Signature]	DATE 3-6-70
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MODEL NO. OPS-1A	PART NO.	SCALE
---------------------	----------	-------

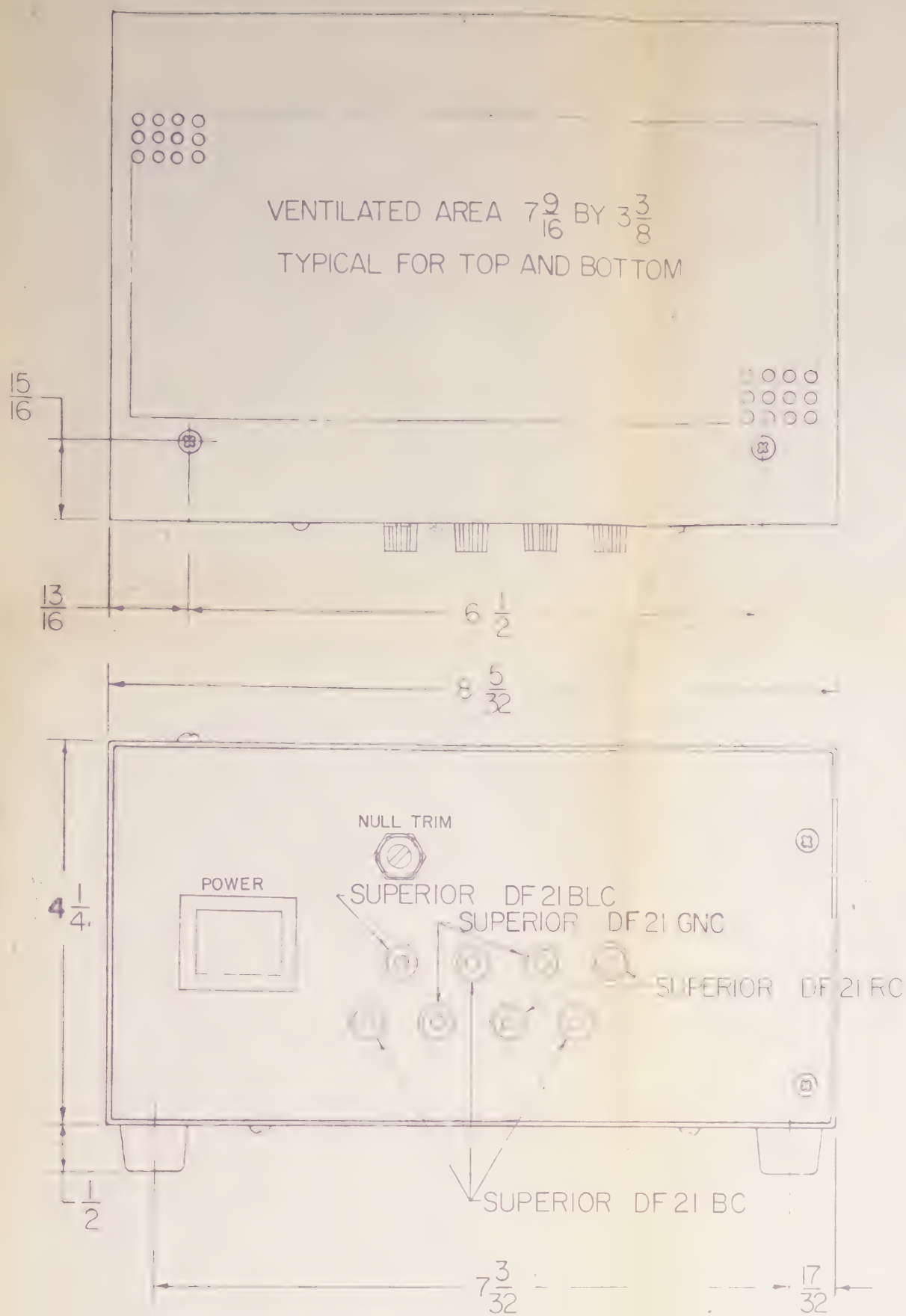
DWG. NO. C SKO-1400

REV	DATE	APP	DATE

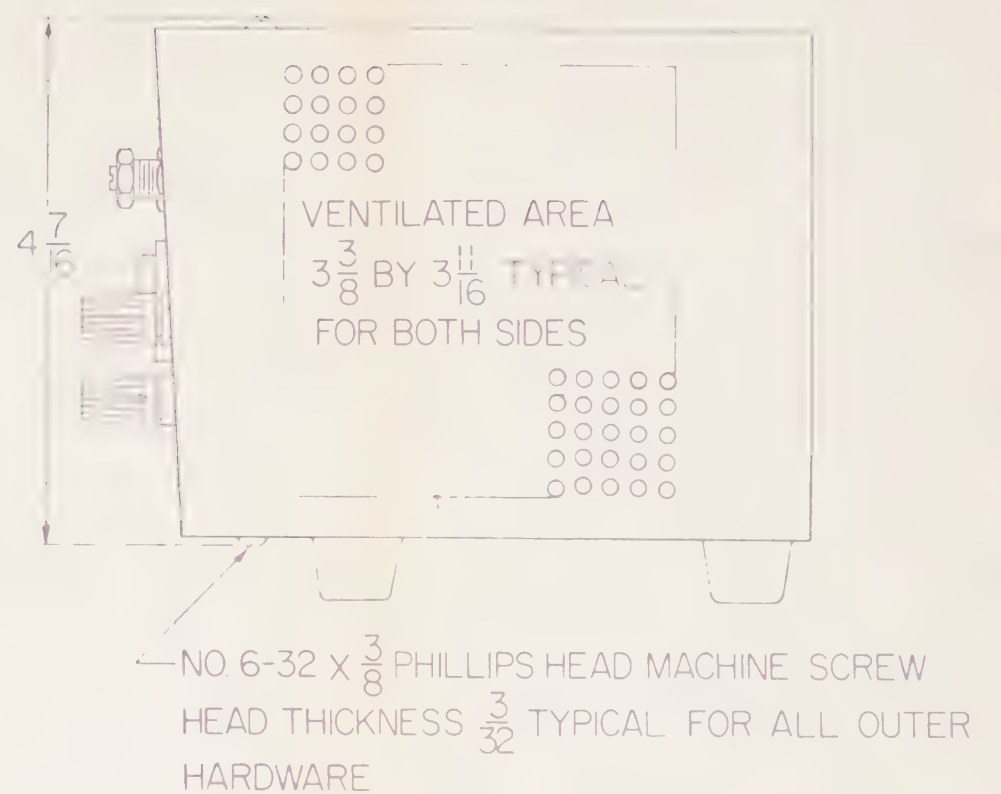
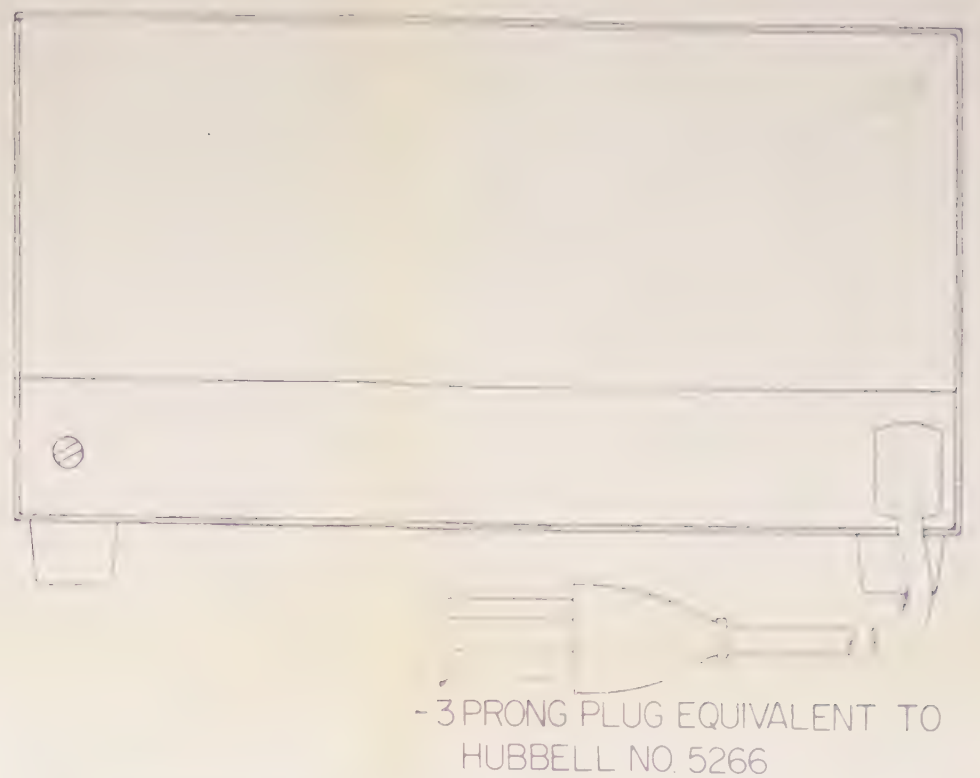
SEE FIG. 5-4 FOR PCB COMPONENT LOCATION



KEPCO INC FLUSHING, N.Y.			
COMPONENT LOCATION			
DRAWN J.S.	CHECKED	APPROVED ✓	DATE 9-29-65
OPS-1A			✓
CM05300			



SEE KEPKO MANUAL FOR ALTERNATE CONNECTIONS

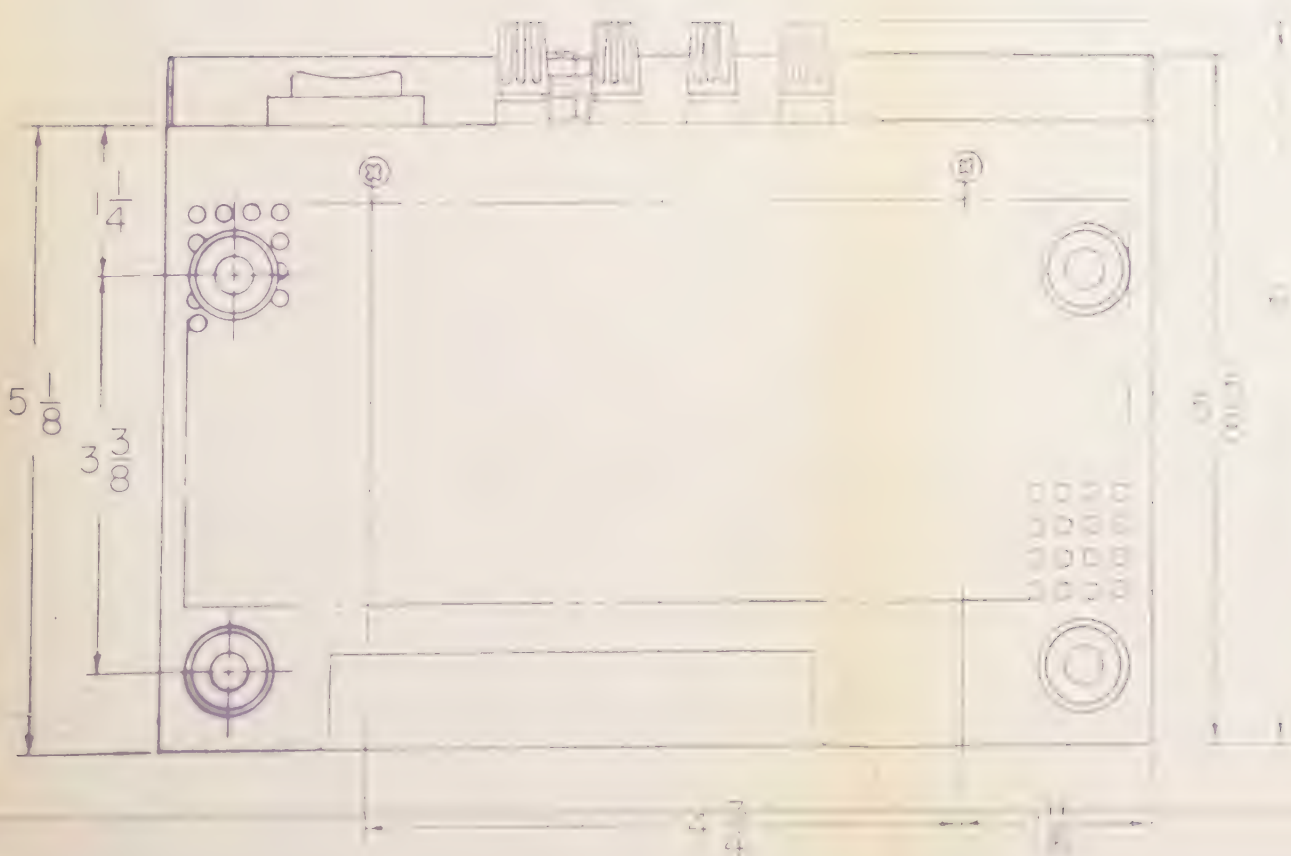


NOTES

1. THIS DRAWING USED FOR OPS-1A

2. MATL., COVER NO. 16 GAUGE COLD ROLLED STEEL
HAMMERTONE FINISH, PANEL ALUM. ALLOY, LIGHT
GRAY FED. STD. 595 COLOR NO. 26440.

3. REFER TO KEPKO CATALOG FOR
DETAILED SPECIFICATIONS



KEPCO INC.
FLUSHING, N.Y.

TITLE
OUTLINE DRAWING

DESIGNED BY H.M. CHECKED BY [Signature] DATE 9-10-67

OPERATOR OPS-1A PART NO. [Signature]

DWG. NO. DMO 5257

REVISIONS

DRAWN

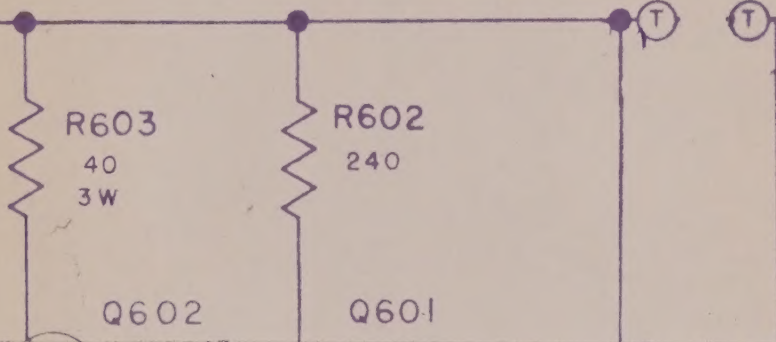
CHKD.

APPD.

DATE

POWER AMPLIFIER

PCB-6



- OUTPUT

+ OUTPUT

- ERROR

St
PUT

R-Y

KEPCO INC.
FLUSHING, N.Y.

TITLE

SCHEMATIC

DRAWN

HDM

CHECKED

APPROVED

DATE

10-11-65

MODEL NO.

OPS-1A

PART NO.

SCALE

DWG. NO.

DMO 5328

OUTPUT POWER STUDY





KEPCO, INC. • 131-38 SANFORD AVENUE • FLUSHING, N.Y. 11352 • (212) 461-7000 • TWX #710-582-2631 • Cable: KEPCOPOWER NEWYORK